"M" SERIES BOMBSIGHT

INTRODUCTION

The Norden Bombsight, known in the Army as the "M" sight, made its appearance in the early 1920's and was turned over to the Air Corps in 1930.. During its relatively short history,it has undergone a number of refinements each of which gave rise to a new model which was indentified by a specific number i.e. M-1, M-2, M-3, etc. Thus, giving rise to the M-series, all of which are Norden sights--each model number simply indicating some refinements over those of lesser number. Exceptions: M-5 and M-7, which are same as M-4 and M-6 respectively, except that they use 24 instead of 12 volts of electricity.

As has been adequately proven in the present conflict, the bombsight is one of the most potent weapons of modern warfare. Placed in the modern bombing aircraft, we might liken it to the aiming mechanism of a highly mobile super cannon. In this analogy the "cannon" (bomber) carries the "shell" (bomb) to within fairly close range of the target, and then, through the medium of the bombsight the "shell" is delivered with incredible accuracy to its objective. Thus, we see that with the modern bomber and M-sight it is possible to deliver to the enemy much heavier blows with far greater accuracy than was ever possible when we had to depend solely on long range big guns.

Since it is a known fact that the greater the distance between relase point and point of impact the greater will be the possible error, it follows that the higher the mission the greater will be our need for a bombsight that can properly aim the bomb so that it will hit the target. Therefore, our precision bombsight becomes an even more important part of our new heavy bombers, as they are constructed to operate most efficiently at higher altitudes than our older, lighter bombers have been operating. The problem solved by the bombsight is that of accurately locating that one point in space at which it is necessary to release the bomb if it is to hit the target. This is accomplished by the M-sight in that it is so constructed that it can slove the proper range and course for a given altitude, air speed and type of bomb, if the bombardier properly handles the controls of the sight.

In handling the controls or any other part of the bombsight. it is well to remember to handle it carefully at all times. It is a high type of precision instrument that must be in perfect adjustment at all times if it is to work properly. Any mishandling of the sight that results in throwing any part of it out of adjustment will affect the possible accuracy of that particular sight. When properly adjusted all parts of the sight work smoothly. Therefore, one should make certain that he never tries to force any of the controls, as he will undoubtedly be twisting some of the machined parts on the inside.

The sight is constructed to operate on a certain voltage of electricity. If more than the correct amount is used, the wires in the sight will be burned out. If less than correct amount is used, the sight will not function properly. It will be impossible to do accurate bombing with it. The early models

of the sight all operated on 12 volts of electricity (M-1, M-2, M-3). Beginning with the M-4, the even numbered sights (M-4, M-6) operated on 12 volts whereas the odd numbered sights (M-5, M-7, M-9, M-11), all operate on 24 volts. Thus, it is highly important that one notes the model number of the sight he is to use before he turns on the electric current to operare it.

GENERAL DESCRIPTION

The M-sight is composed of two main units and an electrical indicator linkage to the pilots instrument panel.

The Sight-head ----- contains the rate end, the telescope motor, the telescope and mirror, the mirror drive machanism, the trail setting mechanism, the cross trail mechanism and the vertical or sight gyroscope and its controls.

The Directional Stabilizer --- contains the azimuth (hotizontal) or stabilizer gyroscope and the servo motor which serves to automatically correct the gyroscope.

The Pilot Direction Indicator --- is an electrical linkage from the bombsight to the pilot's instrument panel. It is simply a device with an indicator on each end (one on the bombsight and one on the instrument panel) that indicates the direction and amount the pilot must turn the aircraft to put it on the proper course.

THE SIGHT HEAD

The Rate End.

As shown in the accompanying diagram (Fig. 2), the mechanism for initiating the rate of drive to the mirror is located in the rate end of the sight, head. The power for the drive is furnished by the telescope-motor. (The term "telescope" is a carry-over from the old model sight wherein the telescope was driven through an arc during the sighting process. A more apt term would be "rate motor"). It is a variable constant speed motor, which means that the speed of the motor can be controlled so that once the speed desired is set, the motor will drive constantly at that one speed.

The rate motor drives a shaft to which is attached a large and a small gear and a governor. The gears mesh with a small and a large gear which float around the dis drive shaft. A clutch is fitted around a square sector of this shaft, which, therefore, rotates when the clutch is engaged with one of the gears. The clutch is moved to engage one or the other gear by the disc speed change lutch (also called Hi-lo shift lever). When the clutch is engaged with the large gear, the disc speed is slow, and *vice versa* when

it is engaged with the small gear so that a high or low disc speed may be had from one speed of the rate motor. A gear on the end of the disc drive shaft meshed with the disc, which is a large gear with a polished face from which the drive is transfered to the rate mechanism.

The governor on the end of the shaft operates in the following manner to keep the motor turning at a constant speed. As the shaft spins, the weights on the governor arms are forced outward from the shaft by centrifugal force. This causes the plunger to be drawn in. That movement shifts the position of the lever which passes up through the disc-speed drum to the contacts in such a manner as to force the contact points apart, which in turn breaks the circuit to the telescope motor. Since the motor no longer is getting any power, it begins to slow down. When it does, the governor arms tend to straighten out, thus forcing the plunger out. Again the lever through the disc speed drum is shifted. This time the contact is closed and so the circuit to the motor is again complete. The motor starts to "rev" up and the whole process is repeated. The net result is that the motor is continuously speeding up and slowing down, causing the contacts to make and break with split second frequency, thus giving a very nearly constant speed to the motor.

The given speed of the telescope motor and therefore, the speed of the disc is controlled through the medium of the disc speed drum. It consists of a coiled "clock-spring" and an external drum calibrated in RPM which the outer end of the spring is attached. The tension of the spring is controlled through the setting of the calibrated drum. The inner end of the spring is attached to the pivotal point of the lever extending from the governor to the contact points. Therefore, the greater the tension set into the spring, the faster the motor will have to travel to force the governor arms to move sufficiently far to overcome the pull of the lever on that end and thus break the contact at the other end. The net result, therefore, is an increased speed of the disc with increase of tension in the disc-speed drum spring, since the disc travels at a rate directly in proportion to the speed of the motor.

The speed of the disc is highly important as it furnishes the drive for the rest of the rate mechanism. Therefore, if it is not correct, the proper rate and proper dropping angle can not be set up, and so, the bomb cannot be accurately aimed for the target.

As a result of the manner in which the sight is geared it is said to have a constant of a certain figure. In the old models M-1, M-2, and M-3 the constant was 4850. In all the other models the constant is 5300. It is possible to find the correct disc speed drum setting simply by dividing the constant by the actual time of fall. The resultant figure will be the revolutions per minute of disc speed --- the proper disc speed drum setting. As will be noted in Figure 2, the drive goes from the disc to the roller. The roller is simply a hard steel wheel that is held in contact with the disc through the pressure exerted on the disc by the small spring just behind it (about #2 pressure). Due to the relationship between the disc and roller, it is possible to control the speed of the roller simply by positioning it on the disc. When the roller is at the center of the disc it will not turn at all regardless of the speed of the disc. However, at any point out from the center it will rotate. Its speed of rotation will be directly proportional to the distance it is from the center of the disc and to the speed of the disc itself. From the roller the drive goes through a series of gears to the differential (also called the T-head assembly, or the spider--

gear). The bevel gears on the T-head shaft are floating gears and will absorb the drive from the roller so long as the mirror drive clutch is not engaged. When that clutch is engaged, it will stop the motion of the bevel gear on the bottom of the differential thus forcing the T-head to "walk" around. This will in turn transfer the drive to the mirror-rack pinion which in turning will cause the mirror rack to move.

As is shown in the diagram it is possible to make the mirror-rack drive by manipulation of the search-knob. It is not possible to use the search knob when the mirror-clutch is engaged. When one turns the displacement knob with the mirror drive clutch engaged, all that is accomplished is a temporary speeding up or slowing down of the drive to the mirror rack.

The M-sight solves the rate (range) part of the bombing problem simply by positioning the roller the proper distance out from the center of the disc (assuming the disc to be travelling at the proper speed) and by properly setting up the automatic release system. The roller positioning is accomplished in two stages--each of which must be absolutely correct. First, it will be noted in Fig. 2 that there is a direct linkage from the trail arm to the screw spindle through the trail-gear and the nut-gear. As the trail arm is moved, the nut gear turns around the spindle bearing which is fastened in the sight head. The nut gear therefore, moves up (or down) and presses the thrust washer up against a small pinion fastened on the screw spindle shaft, thus moving the shaft up or down without turning it. The spindle shaft passes through the nut gear but is not engaged to it. Therefore, when trail is set into the sight by moving the trail arm a certain distance - the screw-spindle will move up a distance proportional to trail. Since the roller carriage is threaded to the screw-spindle, it too will move up a distance proportionate to trail, which means that the roller will have moved an equivalent distance out from the center of the disc. This sets in a part of the rate of drive to the roller. NOTE: The trail mechanism does not move the rate quadrant. 2nd, the balance of the distance the roller is moved out on the disc is accomplished by manipulation of the rate knob which is linked to the screw spindle and rate rack. When the rate knob is turned, it turns the screw spindle causing roller to move up or down and drives rack through the rate-rack pinion. It will be noted in Fig. 2 that, due to the linkage, two things occur whenever the rate knob is turned. a) the roller is positioned on the disc. b) the rate quadrant is moved (the dropping angle is set up). The rate quadrant is moved only by the rate knob. The distance the roller is moved out on the disc by the rate knob is proportional to the speed of closure x ATF-T. The only case when that distance is proportional to Actual Range is when the target is motionless and there is no cross-wind. Hence, it should be clear that the roller must be moved just exactly the right amount by each stage of the positioning procedure if the proper dropping angle is to be set up, and if the bomb is to be released at the proper instant to hit the target.

Rate and Mirror Quadrants.

In Fig. 2 is shown the mechanism for driving the two racks (the mirror rack and the rate rack). Figure 4 shows the two quadrants whose movements are controlled by the movements of the marker. The automatic release mechanism is so constructed that the contacts close at the instant the indices are together.

The rate quadrant does not move except when the rate knob is turned. The index on the rate quadrant indicates the dropping angle that has been set up. Also located on the rate quadrant are the two contacts which close the circuit that causes the bomb to be released.

The index on the mirror quadrant indicates the sighting angle. Since this angle constantly changes during the bombing run, it is necessary that this index, and so the mirror quadrant, moves at a constantly increasing speed as the plane approaches the target. Therefore, if the rate index indicates the correct dropping angle, it must remain stationary once it is set, and if the mirror index indicates the sighting angle it must be constantly moving during the bombing run, and if the bomb is released when the two indices meet, it follows that the bomb is released when the sighting angle is equal to the dropping angle. Both quadrants are tied by studs to their respective racks. The stud of the mirror quadrant slides in a groove as the quadrant drives and thus the rate of drive is speeded up as the plane approaches the target. The automatic release contacts are held apart by the fact that the movable one (Fig.4) rides against the edge of the mirror quadrant until the release notch moves up to it, at which time the spring pulls it against the other contact (if the trigger is being held up), thus closing the circuit and sending current to the bomb racks to drop the bomb.

The displacement knob is geared to the lower gear of the differential when the mirror clutch is engaged. As the displacement knob is turned, it speeds up or slows down the movement of the mirror to place the crosshair on the target.

Mirror Cable Drive

The inner arc of the mirror quadrant is geared to mesh with a gear rigidly fastened to the shaft that carries the first sheave or cable drum. Therefore, as the quadrant is driven by the rack, it causes the cable to be wound or unwound on the drum. One end of this bronze cable is attached to the #1 sheave, and passes from there around #2 sheave, thence through the pivot point of the cardan gudgeon bearing of the vertical gyro around #3 sheave, thence around #4 sheave through the pivot point of the telescope cradle gudgeon bearing to # 5 sheave to which the other end is attached. On the other end of the shaft to which #5 sheave is fastened is a gear which meshes with the mirror drive sector. The mirror is attached to the bottom of the sector. Thus we see that the drive that is picked up by the roller from the disc is passed along at just such a rate, by way of the differential, mirror rack, mirror quadrant, and set of sheaves that it causes the mirror to pivot through an arc at a rate determined by the speed of closure and the altitude as the cable winds up on the #1 sheave.

There is another short bronze cable attached by one end to the mirror sector, the other end is attached to the #6 sheave which is fastened on one end of a shaft which passes through the telescope cradle housing. On the other end of this shaft is a drum containing a coiled "clock-spring". As the long cable is caused to wind up on the #1 sheave, the short cable is unwound from #6 sheave, at the same time the spring is "wound-up". Thus, when the mirror is driven through its arc during the bombing run a tension is put on the spring.

sufficient to keep both cables tight and in place during the process of returning the mirror to its original position through use of the search knob. (returning the mirror index to 70°).

Extended Vision

On the same shaft as that to which are fashioned the #1 sheave and the #1 sheave gear is another gear known as the extended vision (extreme forward vision) gear. Its movement is controlled by the extended vision knob. The purpose of extended vision is to give an added 20° of forward angle of sight over the customary 70° obtained by normal operation of the optical system. It is used when it is necessary to "pick up" the target sooner than would be possible with only 70° of forward vision such as in low altitude bombing or extremely long bombing runs.

Directional Stablizer and Servo Unit

The directional stablizer is composed of two units. The horizontal gyroscope (spin axis is in the horizontal) with a speed of 7000 R.P.M. gives stabilization in direction (azimuth) to the sight head and thus to the optical system of the sight. The servo unit keeps the gyroscope from processing by applying a corrective pressure (torque) to the cardan (Middle gimbal ring) the instant the spin axis gets out of the horizontal.

A s shown in Fig. 7 the servo unit is composed of the servo motor which turns constantly while the stablizer is operating. It is linked by gears to the clutch gears which are kept turning constantly in opposite directions. Thus, when one of the solenoids is activated by an electrical impulse from the gyroscope (indicating that it has processed), the solenoid attracts the clapper magnet which forces the cork faced clutch up against the turning clutch gear. This causes the intermediate gear to attempt to turn. However, it cannot turn as it is meshed with the procession gear which is fastened to the cardan. Therefore, it simply results in a torque being put on the cardan which will cause it to correct the gyro.

If the gyro axis has moved down, the other solenoid will be activated. Thus, depending on which way the axis moves the proper solenoid will act to produce a torque action from the correct clutch gear to correct the procession. An impulse is obtained from the gyroscope whenever the Isolated sector brush is caused to move either up or down (by the procession of the gyro) from the dead spot in the center to the electrically charged area on either side of the center. In the M-4 and M-6 sights, if the procession is slight, the brush will contact the 6 volt area on either side of the center. If it is considerable, the brush will contact the 12 volt area beyond the 6 volt area and thus will initiate a larger corrective torque to the cardan. In the M-5 M-7 and M-9 sights the voltages on the two areas are 12 volts and 24 volts respectively.

Stabilization for the sight head is obtained from the stablizer through the directional or the secondary clutch either of which ties the two units together when engaged. They are attached to an extension of the cardan and are thus stablized by the action of the gyro.

Optical System and Sight Gyro

The optical system is composed of a low powered telescope with cross-hairs etched on a lens, a small but excellent mirror for picking up the target, and a small many-faced prism through which the image is reflected from the mirror to the telescope. There is a small light used for illuminating the cross hairs at night. Its brilliance is controlled by a rheostat located conveniently on the rear of the sight-head.

Stabilization against pitch and roll for the optical system is obtained through the vertical or sight gyroscope. The spin axis of this gyroscope is in the vertical, its speed of rotation is 7800 RPM. There is a simple straight arm linkage from the gyroscope to the telescope to give stabilization against roll. Stabilization against pitch is assured by the fact that the telescope is mounted in a cradle which in turn is mounted in the gyroscope cardan which serves as the middle gimbal ring of the gyroscope. There are bubble levels on the gyro housing (inner gimbal ring) to indicate precession or lack of level in either fore and aft or in lateral directions. It is essential to keep a close watch on the bubbles during the bombing run to make sure the gyroscope is level when the bomb is released, because if the gyroscope is not level, neither will the telescope be properly aimed. Level corrections are made with the two levelling knobs. One on the left end of the sight head for the fore and aft bubble extends through the pivotal point of the cardan and works on the gyroscope housing. The other extends through the sight case, if for the lateral bubble, and works on the cardan.

Crosstrail Mechanism.

The Cross Trail mechanism is rather complicated in that it involves movements in three different planes. It is easiest to explain through use of a mock-up. It consists of a dove-tailed bar fashioned to the top of the inner part of the sight stem. This inner part of the stem is locked to the directional stabilizer by the sight stem locking pin. Therefore, it cannot move with the sight head but rather turns with the stabilizer. The long dimension of the dove-tail bar is always in the fore and aft direction of the aircraft. Fitted over the dovetailed bar (and thus the name dovetail) is a small disc shaped part with a lug on the top. Whenever the center of the disc is directly over the center of the dovetail bar, the lug will have the same radius of turn as does the center of the dovetail bar. However, if the disc is slipped fore or aft of the middle of the bar the lug will then have a greater radius of turn than the center of the bar. The lug on the disc extends up through the positioning arm and through the cross-trail carriage. The trail positioning arm is linked to the trail arm and so moves the disc whenever trail is put into the sight. Since the disc is dovetailed to the dovetail bar, its lug will turn through a radius determined by the distance it has been moved from the center of bar. That distance will be proportional to trail. When it so moves it will cause the cross-trail carriage to move with it. The cross-trail carriage in turn is linked through a bell crank to the telescope and so the telescope too must move (tilt). Therefore, as the stabilizer turns under sight head as the plane turns upwind to correct for drift, the telescope will be tilted so that the plane will

cross-trail distance upwind of the target. If no trail is set in, the telescope will not tilt.

Course Knob Assembly

The Schematic diagram of the course knobs will serve well to help in explaining their purpose. They are known as the <u>turn knob</u> (outer) which serves to change the angular relationship of the sight head with the stabilizer gyroscope and the <u>drift knob</u> (inner) which serves to indicate the amount the aircraft must be "<u>crabbed</u>" into the wind to make it "track" properly. The turn knob shaft has a worm gear on the opposite end from the knob which meshes with the stabilized sector. The sector in turn is tied to the directional stabilizer gyro) through the directional connecting rod and the directional clutch. Thus, when the turn knob is turned while the directional clutch is engaged, the stabilizer sector cannot move, therefore, the sight-head has to turn accordingly, and so the angular relationship between sight-head and stabilizer gyro is altered.

The drift knob shaft has a gear fastened to the end of it which in turn meshes with another gear on the same shaft as the drift worm. Therefore, when the drift knob is turned in one direction the drift worm turns in the opposite direction. The drift worm meshes with the drift gear to which is attached the P.D.I. brush. The sole purpose of the drift assembly is to put through an indication to the pilot (either auto or manual) of the amount and direction necessary to "crab" the aircraft into the wind to "kill" no drift. When the turn knob above is turned there is also an indication set through by the P.D.I. because the sight head turns carrying the drift worm with it which has the same effect as turning the drift knob and the pilot makes the necessary correction.

Due to the difference in the gearing of the two knobs assemblies, the same amount of simultaneous turn on the knobs (double gripping) will produce the following difference in results. The drift knob will turn the drift gear $5\frac{1}{2}$ times as far as the turn knob will turn the sight head with the same amount of turn put on both knobs. Which means that when there is a one degree turn put into the knobs (double gripped) the sight head will be displaced 1° with relationship to the directional stabilizer and will drag the drift gear around a like amount. At the same time the drift gear will be turned through $5\frac{1}{4}^{\circ}$ by the drift knob which means that there will be a $6\frac{1}{4}^{\circ}$ turn indicated by the P.D.I. However, since the turn knob set up an initial displacement of 1° between sight head and stabilizer, when the pilot wipes out the $6\frac{1}{4}^{\circ}$ turn indicated he has moved the ship (stabilizer) under the sight head so that only a $5\frac{1}{4}^{\circ}$ displacement remains between head and stabilizer. Thus, the prime function of the turn knob is to keep the fore and aft cross hair on the target, whereas that of the drift knob is to assist the pilot to properly kill the drift.

PILOT DIRECTION INDICATOR (P.D.I.)

The Pilot Direction Indicator is the system which informs the pilot what corrections in course are to be made. It consists of two parts. The first is the Bombardiers part which is mounted in the stablizer case and the second the Pilot's PDI which is on the pilot's instrument panel. The bombardiers PDI is essentially a potentiometer. That is, it consists of a coil of wire and a metal strip or wiper which slides over the coil and makes contact with different parts of the coil. The coil is fastened rigidly to the stablizer case and the wiper turns with the stabilized brush collar and moves whenever the bombardier puts in a correction with either course knob. If the wiper is at the center of the coil no current flows to the pilots PDI and the needle therefore stands at zero. If the Bombardier turns either knob clockwise the wiper moves to the left. This send an electric current to the needle on the Pilot's PDI and the needle there moves toward the right. This is a signal for the pilot to turn the plane towards the right. As the plane turns the coil moves under the wiper until the wiper is over the center of the coil and the current to the Pilot's PDI is off. A counter-clockwise turn of a course knob gives a current in the opposite direction and the pilot turns the plane towards the left. If an air current should throw the plane off course the wiper, which is stablized by the stabilizer gyro, stays still. The coil moves with the plane. As soon as the wiper is off of the center of the coil, the pilot gets and indication and he corrects the course.

Errors:

Tell where a bomb will hit if each of the following errors are made and explain briefly what happens in the bombsight.

A. Wrong dropping angle set on sight.

B. Wrong trail setting on the sight.

C. Wrong disc speed on the sight.

D. Plane flying at wrong altitude.

E. Plane flying at wrong air speed.

F. Wrong drift set into the sight.

G. Effect the Range component of cross trail

H. Extended vision unintentionally left in.

I. Roller slippage while synchronizing.

J. Plane moving upwards.

K. Plane moving downwards.

Preflight Check

A. Go over each step in the preflight check as practiced on this field and explain why each step is used and demonstrate how it is done.

PRE-FLIGHT INSPECTION
(M-SERIES BOMBSIGHTS)

INSPECTED BY: ______________________ DATE ______________ CLASS ____________

______ 1. Mount sight and check Bombsight clutch connecting arm and dovetail locking pins for security.

______ 2. Turn on stablizer switch. (Do not turn on any other switches for at least 3 minutes).

______ 3. Check action of rate knob, displacement knob and search knob through entire range.

______ 4. Check action of extended vision knob.

______ 5. Turn on DC switch and check for bubble and cross hair lights. (Rheostat turned clockwise for cross hair light)-(night bombing).

______ 6. Turn on rate motor switch and check to see that tachometer adapter rotates.

______ 7. Clutch in optic clutch and check drive of optics.

______ 8. Check proper action of D.S. gear shift and check action of altitude knob through entire range.

______ 9. Check for pre-set trail - (Rate index minus .05, (first marker beyond zero) maximum disc speed, telescope index at a very small dropping angle. Clutch in optics clutch, set trail arm on 50 miles - telescope index should stop moving). Return altitude knob to low. Disc speed position.

______ 10. Check D.S. at different altitude settings and note error on altitude drum. Set up proper D.S. and switch off rate motor.

______ 11. Level stabilizer (bubbles level caged) uncage gyro, level sight gyro checking the freedom of leveling knobs and watch gyro for precession 1½ minutes. (Precession should not exceed one fourth a bubbles length (9 mils) in 1½ minutes.)

______ 12. Turn on torque motor; clutch in bombsight clutch and apply torque to sight in both directions to check action of torque motor. (Sight should resist turning).

______ 13. Rotate drift and turn knobs to check freedom of movement and amount of P.D.I. action with each.

______ 14. <u>Check Optics Tilt:</u> Turn bombsight to maximum drift angle. Look through optics and turn trail arm to 100 mils. The fore and aft crosshair should move out transversely. Turn trail arm back to zero; fore and aft crosshair should swing back to original position. Repeat operation with opposite drift setting. (If drift is right the fore and aft hair will move to the right. If drift is left fore and aft hair will move to the left).

PRE-FLIGHT INSPECTION (M-SERIES BOMBSIGHTS)

________ 15. Check dovetail alignment - (Set zero drift and tele. index at a small dropping angle). Move trail arm from zero to 100 mils a few times and watch fore and aft crosshair. Fore and aft crosshair should not move).

________ 16. Check for pre-set trail in CT mechanism - (Set trail arm zero and remove dovetail pin. Rotate bottom of stem back and forth and watch fore and aft crosshair. Fore and aft crosshair should not move.

________ 17. Check PDI with pilot's P.D.I. through interphones.

Were there any malfunctions present?______ If so what were they?

____

____

Was malfunction reported to BSM?________

Was Malfunction corrected?________ If so by whom?____________________

____

MISSION NO. ________________	DATE ________________
ALTITUDE ________________	PILOT ________________
SHIP NO. ________________	SIGHT NO. ________________

SCHEMATIC: DISC DRIVE SYSTEM

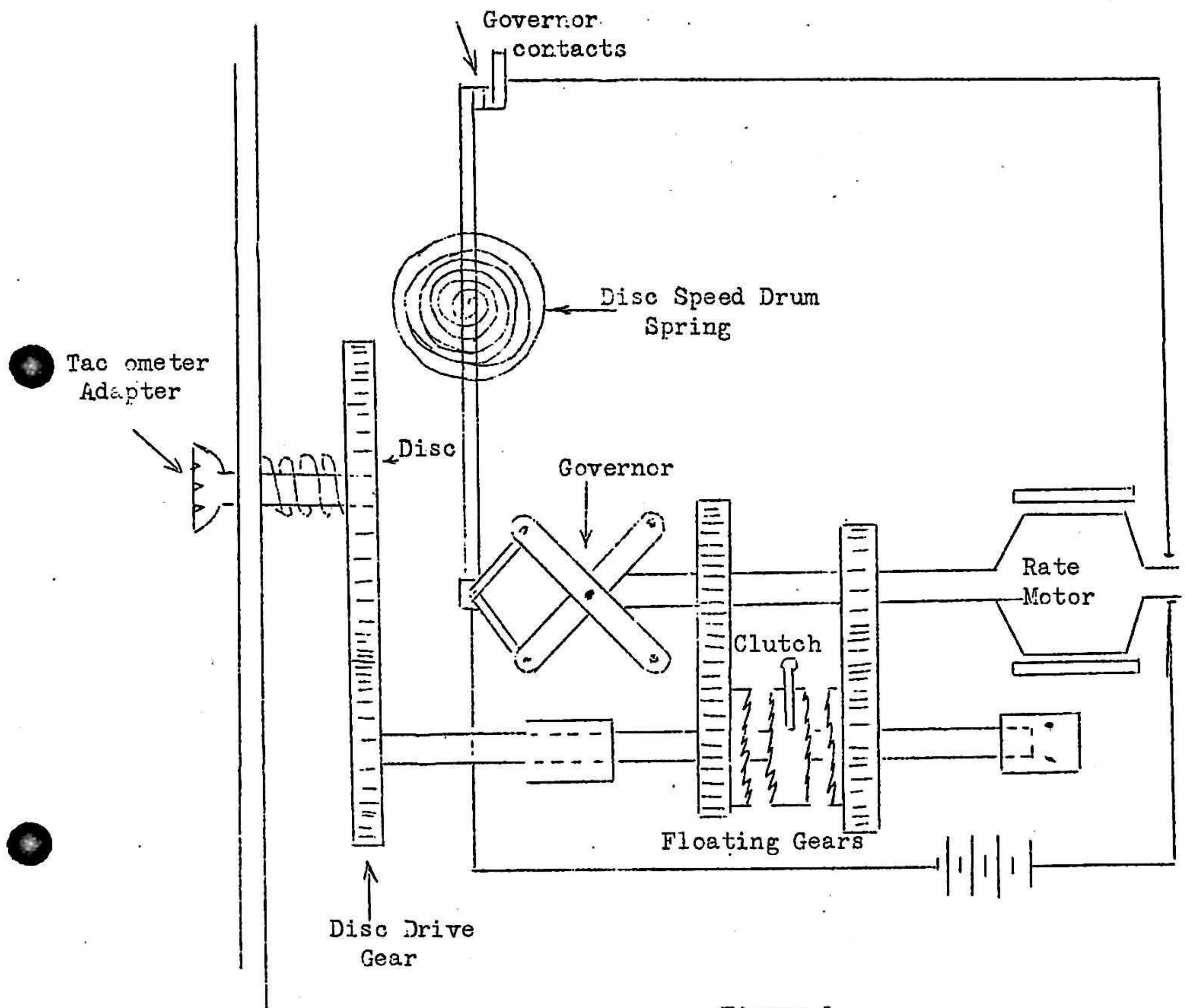


Figure 1

SCHEMATIC: MIRROR DRIVE AND RATE POSITIONING

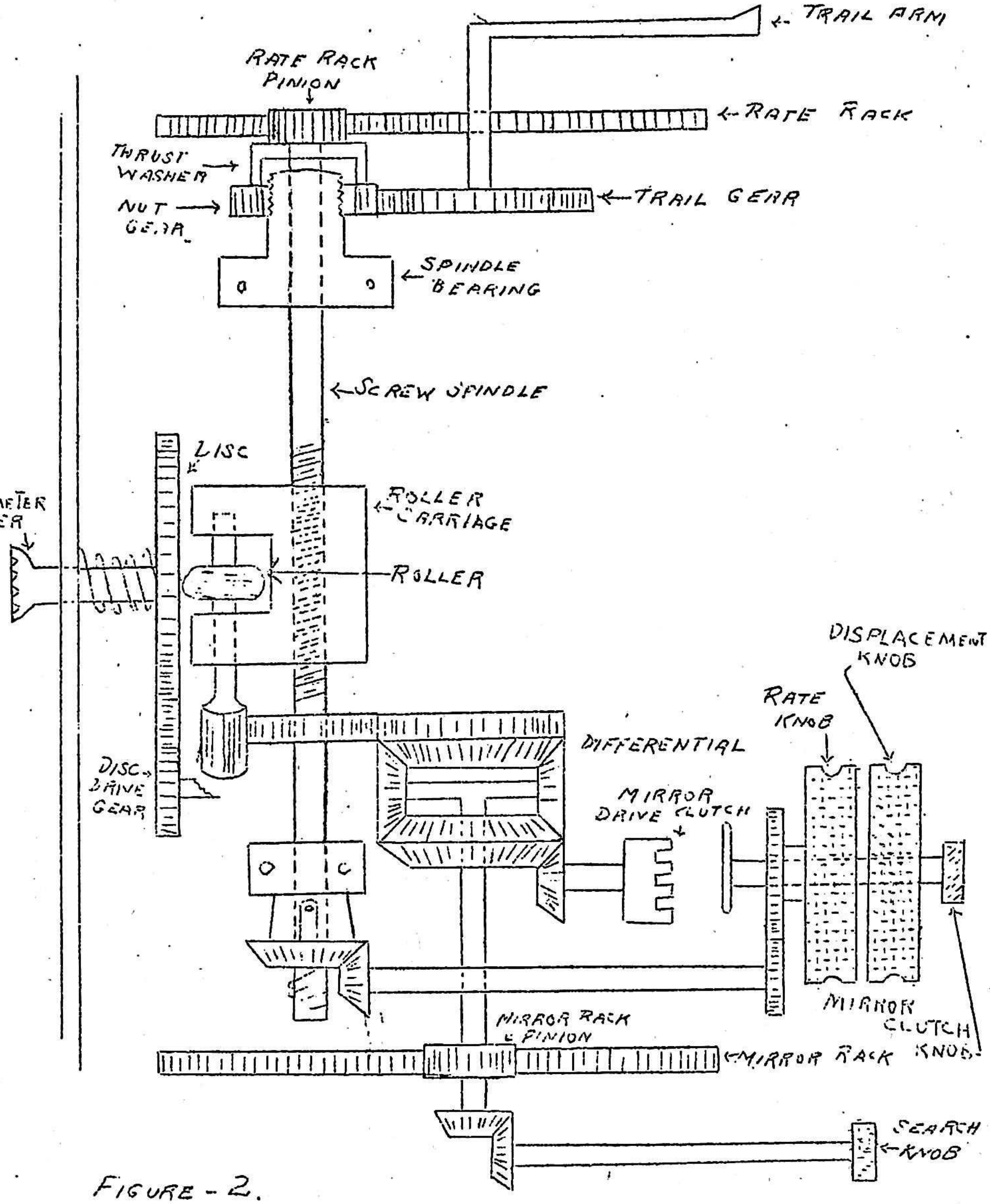


FIGURE - 2.

RESTRICTED

SCHEMATIC: MIRROR AND RATE QUADRANT'S

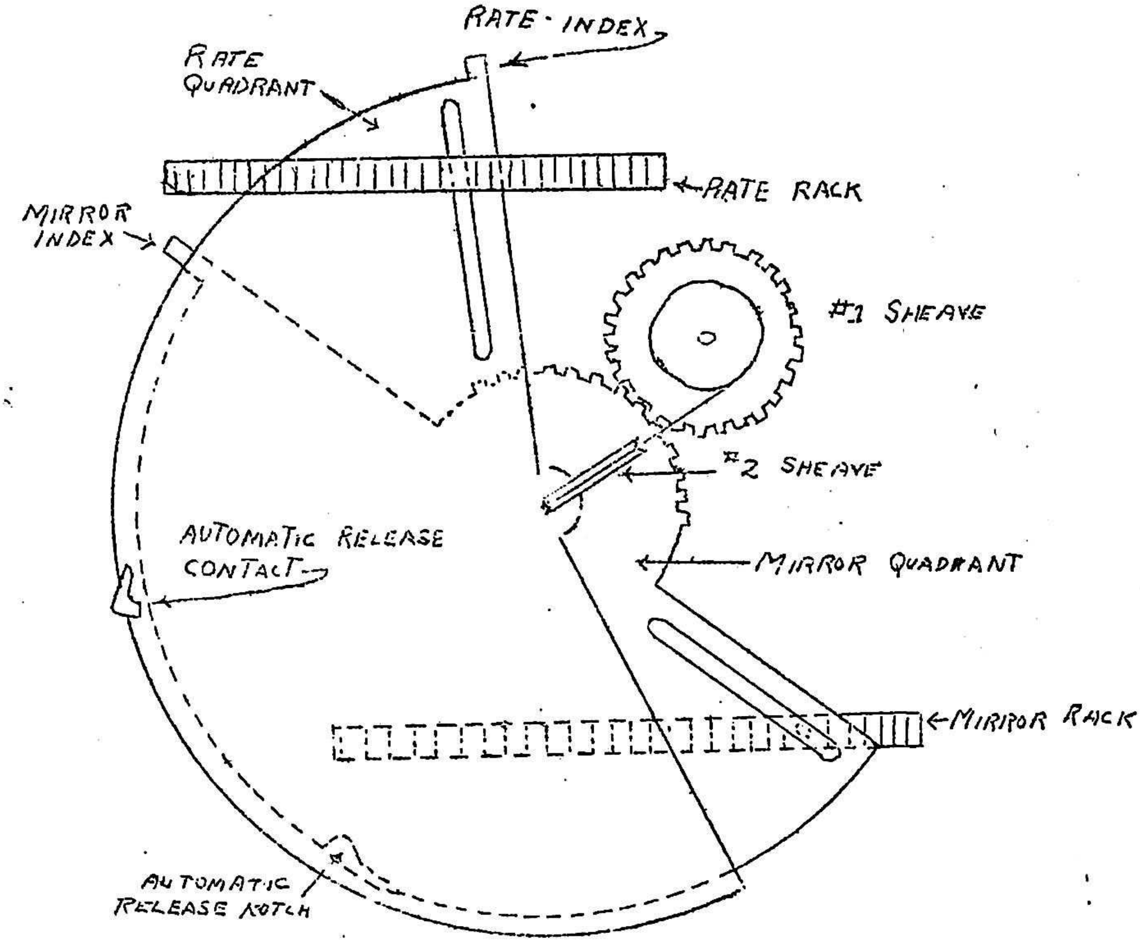
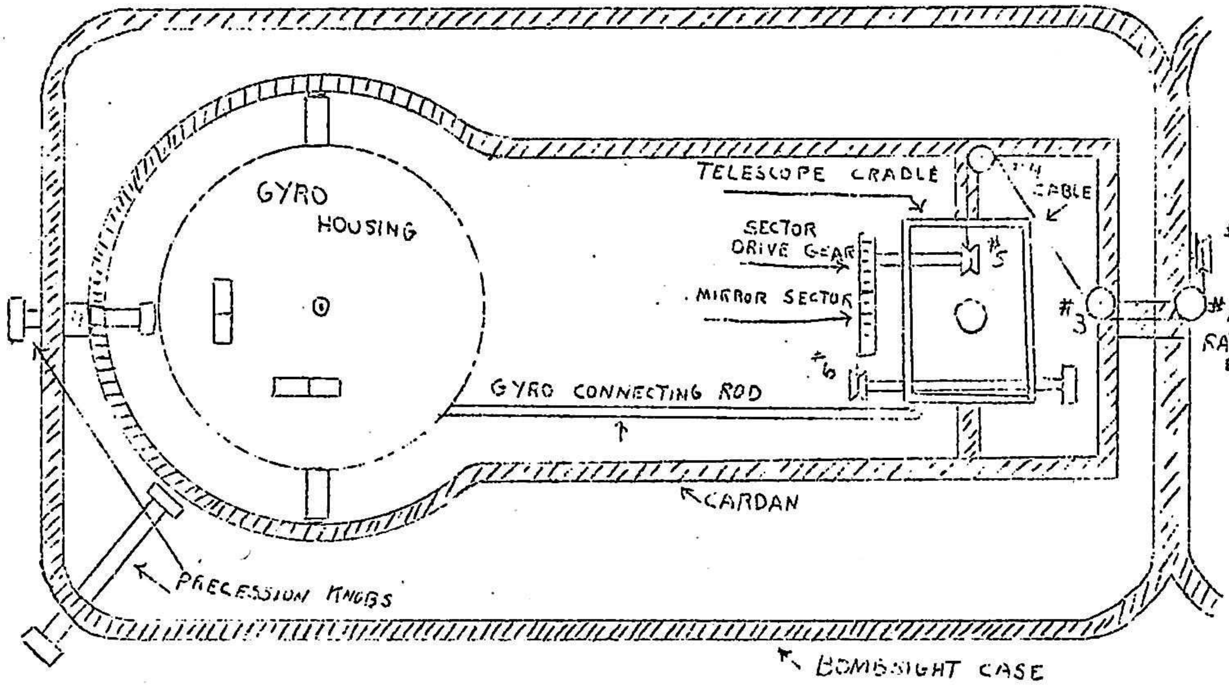


FIGURE 3

RESTRICTED

SCHEMATIC: BOMBSIGHT GYRO AND CABLE DRIVE TO MIRROR



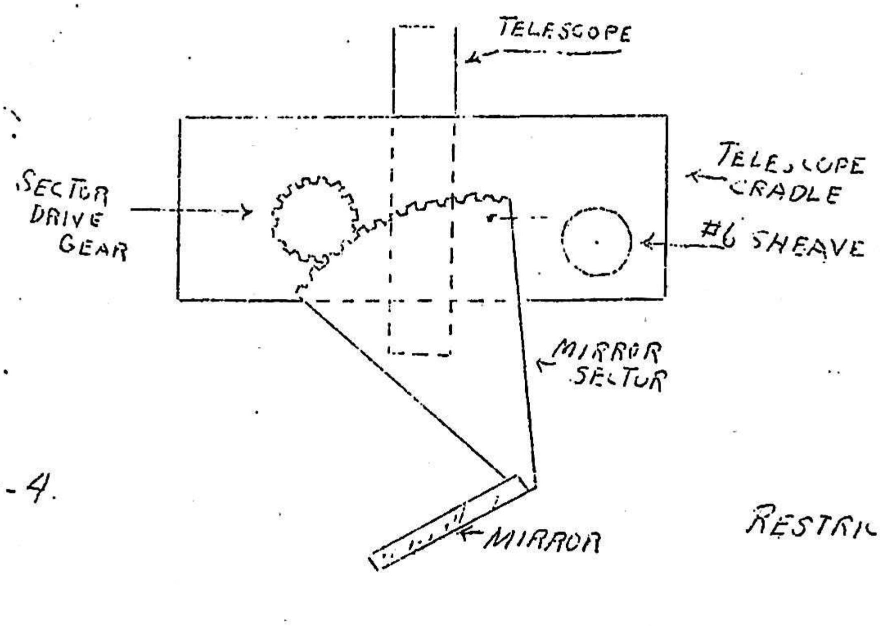


FIGURE-4.

RESTRICTED:

SCHEMATIC: COURSE KNOBS.

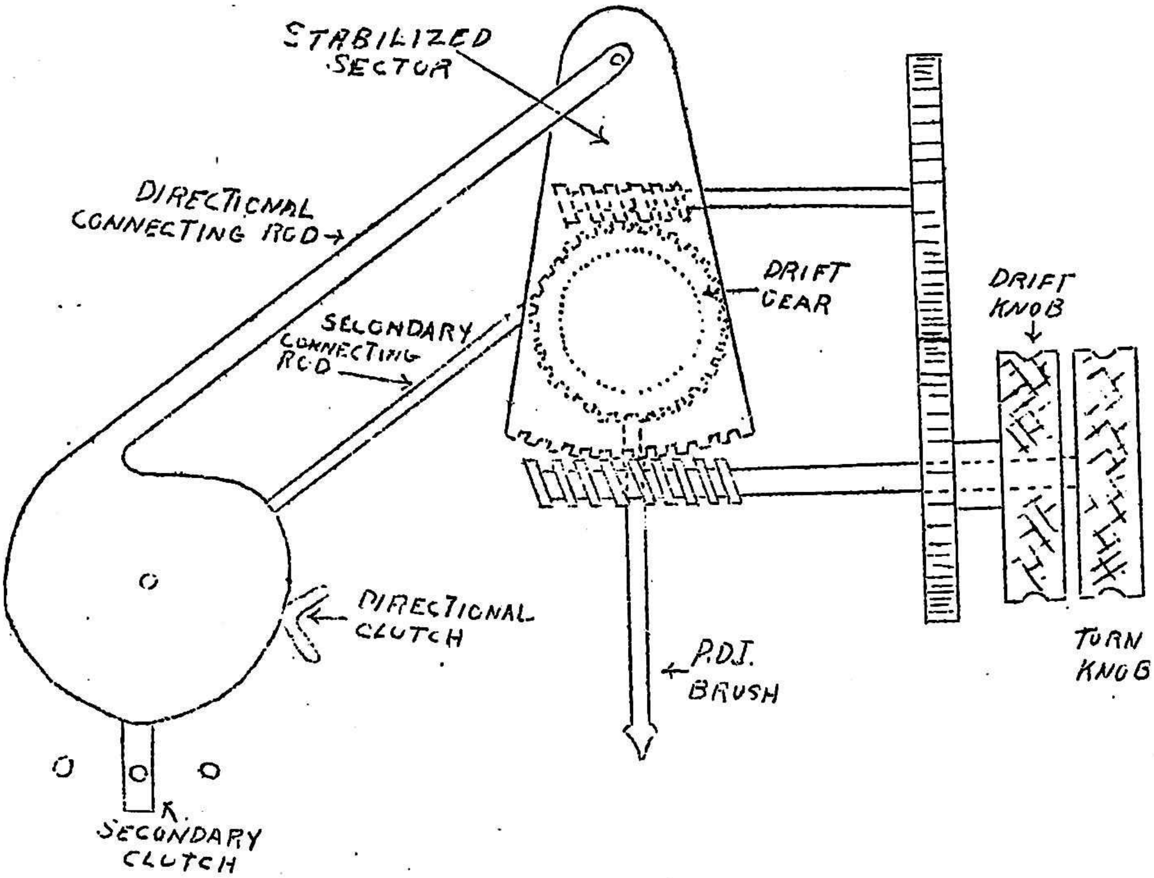
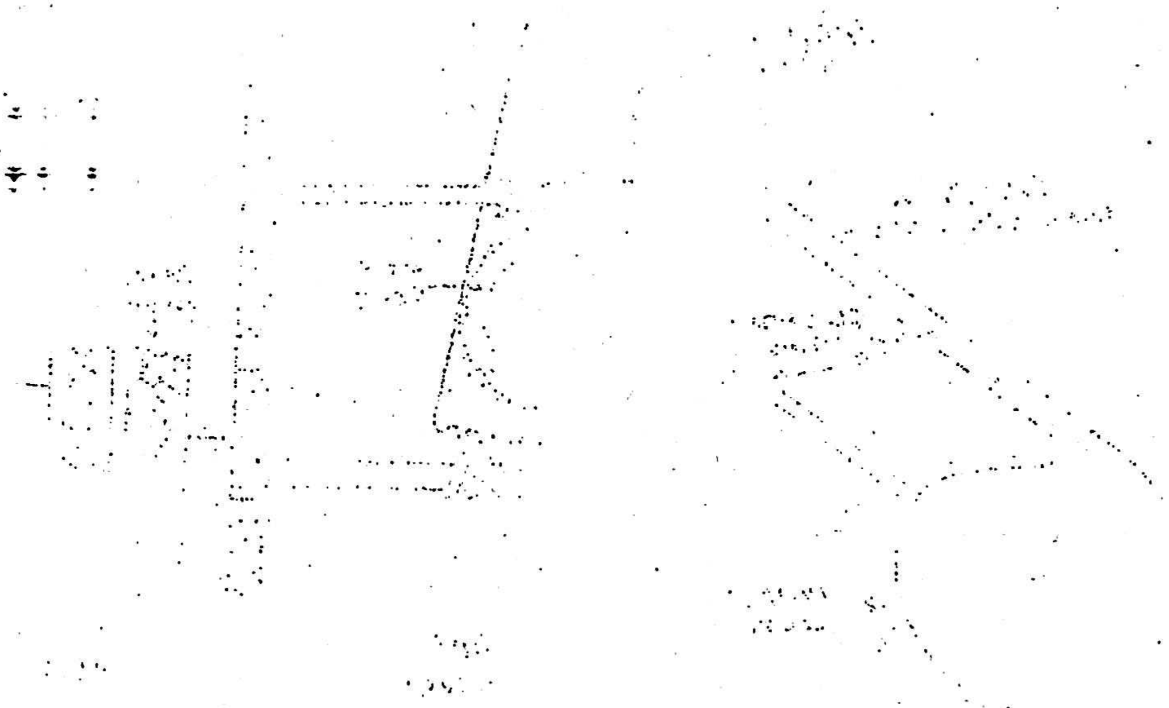
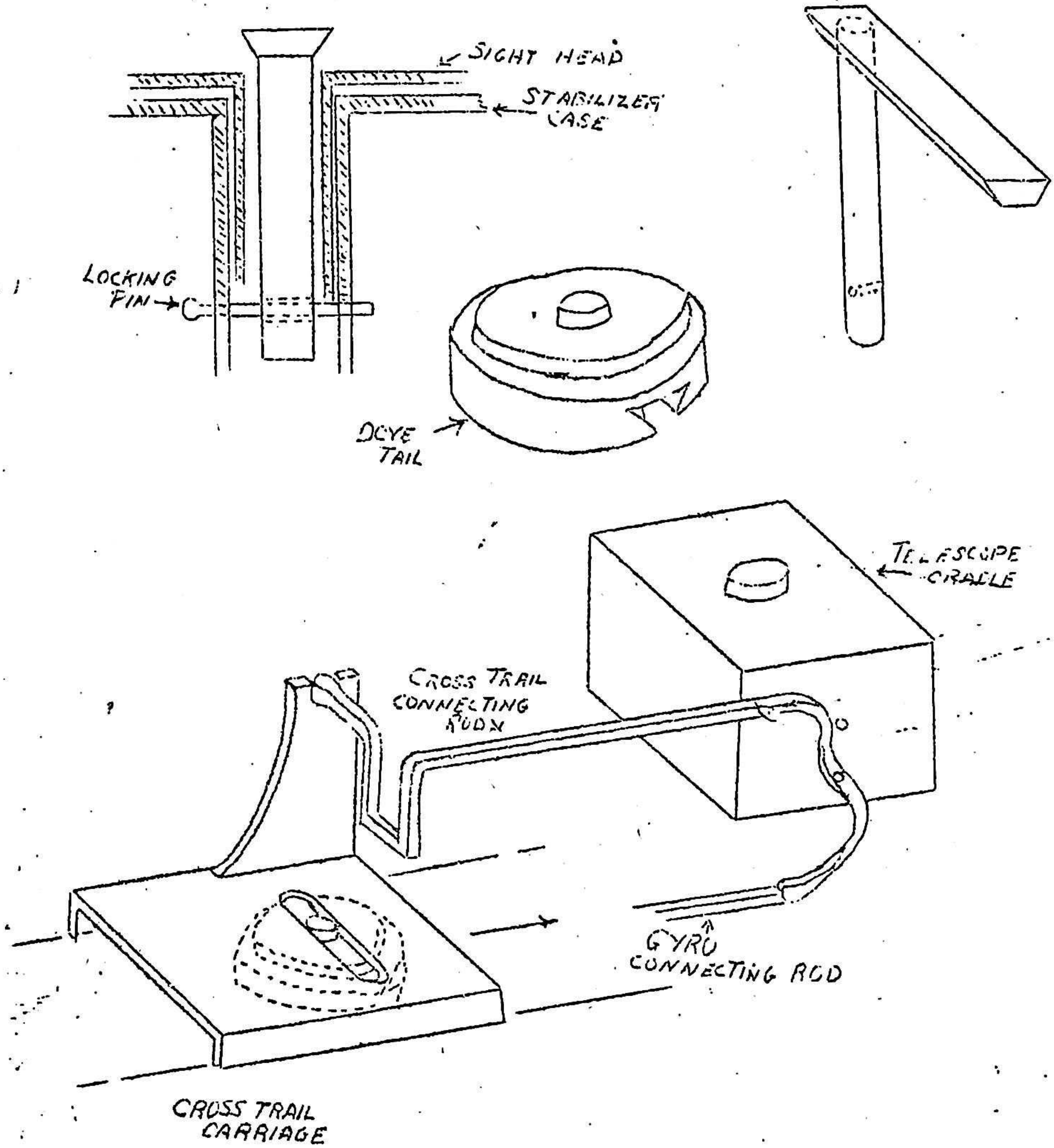


FIGURE 5

RESTRICTED



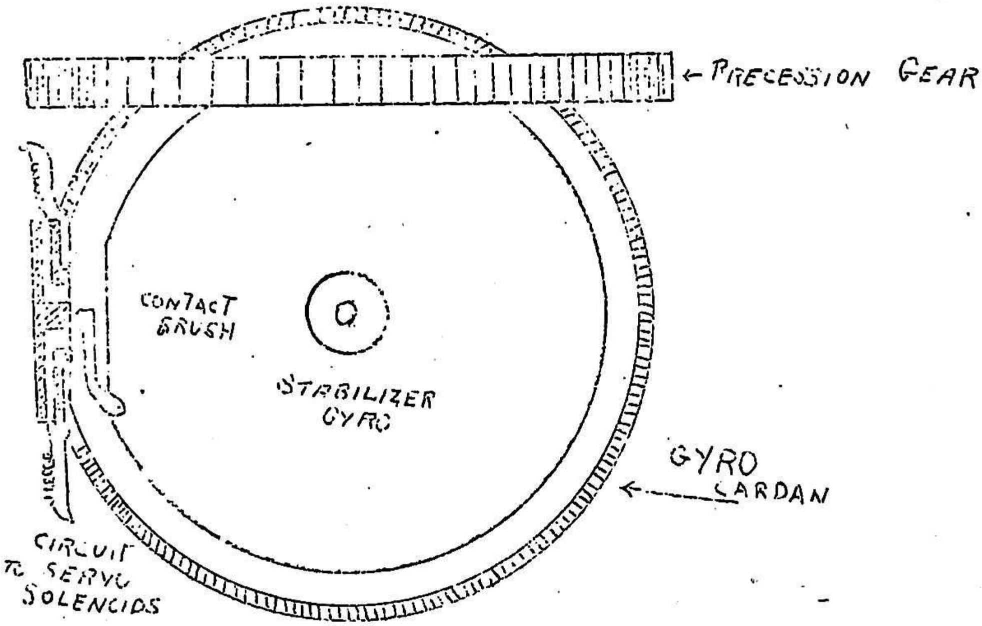


SCHEMATIC: CROSS TRAIL MECHANISM

FIGURE—6.

RESTRICTED

SCHEMATIC: STABILIZER GYRO AND SERVO UNIT



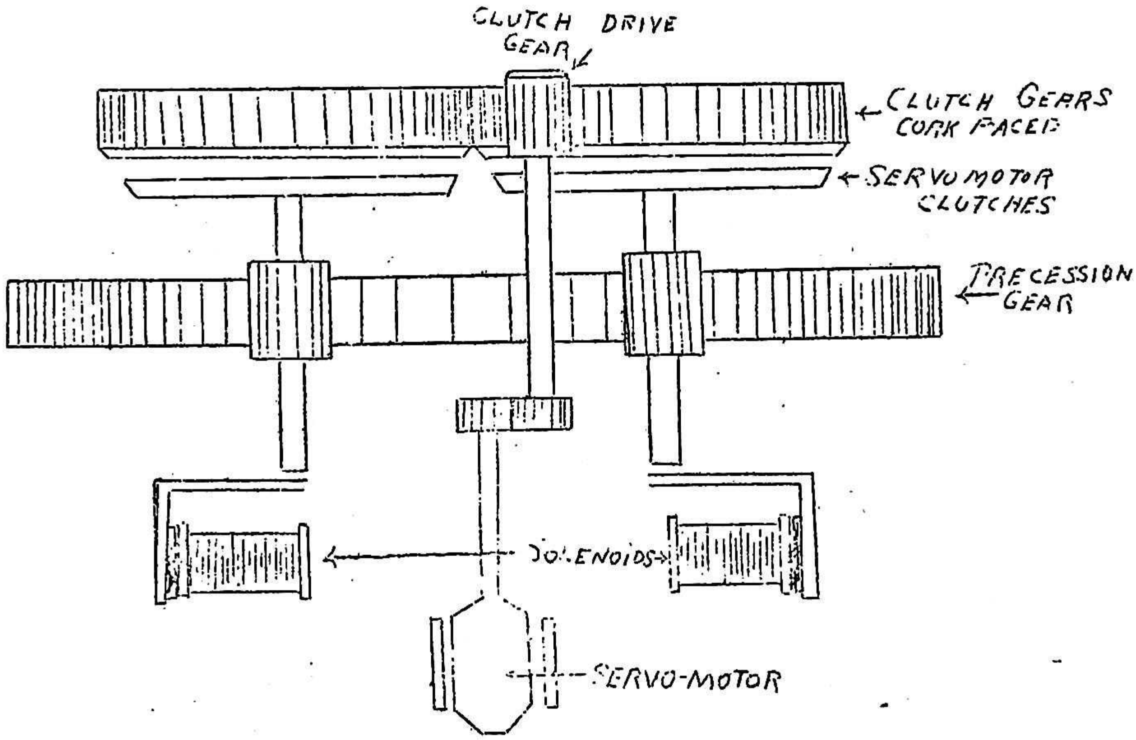


FIGURE-7.

RESTRICTED